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U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

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TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

09/743560

INTERNATIONAL APPLICATION NO.
PCT/JP99/03620INTERNATIONAL FILING DATE
July 5, 1999PRIORITY DATE CLAIMED
July 10, 1998

TITLE OF INVENTION

SAMPLE OBSERVATION METHOD AND EQUIPMENT

APPLICANT(S) FOR DO/EO/US

KENJI OBARA, YUJI TAKAGI, ATSUSHI SHIMODA, RYOU NAKAGAKI, SEIJI ISOGAL (cont. below)

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☐ is attached hereto (required only if not communicated by the International Bureau).
 - b. ☒ has been communicated by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
 - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
 - b. ☐ have been communicated by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 16 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
(inventor names continued: YASUHIKO OZAWA, HIDEKA BANBA, KENJI WATANABE, CHIE SHISHIDO)
IPER, ISR, 9 sheets drawings

U.S. APPLICATION NO. (if known) 37 CFR 1.53

INTERNATIONAL APPLICATION NO
PCT/JP99/03620ATTORNEY'S DOCKET NUMBER
16869P-019100US17. ☒ The following fees are submitted:**BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :**Neither international preliminary examination fee (37 CFR 1.482)
nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO
and International Search Report not prepared by the EPO or JPO \$1000.00International preliminary examination fee (37 CFR 1.482) not paid to
USPTO but International Search Report prepared by the EPO or JPO \$860.00International preliminary examination fee (37 CFR 1.482) not paid to USPTO but
international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$710.00International preliminary examination fee paid to USPTO (37 CFR 1.482)
but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00International preliminary examination fee paid to USPTO (37 CFR 1.482)
and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00**ENTER APPROPRIATE BASIC FEE AMOUNT =****CALCULATIONS** PTO USE ONLY

\$ 860

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30
months from the earliest claimed priority date (37 CFR 1.492(e)).

\$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE
Total claims	15 - 20 =		X \$18.00
Independent claims	9 - 3 =	+6	X \$80.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ \$270.00

\$

\$ 480

\$

TOTAL OF ABOVE CALCULATIONS =

\$ 1,340

☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above
are reduced by 1/2.

\$

SUBTOTAL =

\$

Processing fee of \$130.00 for furnishing the English translation later than ☐ 20 ☐ 30
months from the earliest claimed priority date (37 CFR 1.492(f)).

\$

TOTAL NATIONAL FEE =

\$ 1,340

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be
accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property +

\$

TOTAL FEES ENCLOSED =

\$ 1,340

Amount to be
refunded:

\$

charged:

\$

a. ☐ A check in the amount of \$_____ to cover the above fees is enclosed.b. ☒ Please charge my Deposit Account No. 20-1430 in the amount of \$ 1,340 to cover the above fees.
A duplicate copy of this sheet is enclosed.c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any
overpayment to Deposit Account No. 20-1430. A duplicate copy of this sheet is enclosed.**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

Robert C. Colwell
Townsend and Townsend and Crew LLP
Two Embarcadero Center, 8th Fl.
San Francisco, CA 94111

SIGNATURE:

Robert J. Bennett

NAME

27,533

REGISTRATION NUMBER

09/743560

PATENT

Attorney Docket No.: 16869P-019100US

Client Reference No.: 219800526US1

528 Rec'd PCT/PTO 09 JAN 2001

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re U.S. National Phase of
PCT/JP99/03620 of:

KENJI OBARA, et al.

Application No.: Not yet assigned

Filed: Herewith

For: SAMPLE OBSERVATION
METHOD AND EQUIPMENT

PRELIMINARY AMENDMENT

San Francisco, CA 94111
January 9, 2001

Box PCT
Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination of the above-referenced application, please enter the following amendments and remarks.

IN THE CLAIMS:

Claim 3, line 1, please delete "or 2".

Claim 5, lines 1-2, delete "any one of claims 1, 2, 3, and 4" and substitute therefor --claim 1--.

Claim 6, lines 1-2, delete "any one of claims 1, 2, 3, and 4" and substitute therefor --claim 1--.

Claim 7, lines 1-2, delete "any one of claims 1, 2, 3, and 4" and substitute therefor --claim 1--.

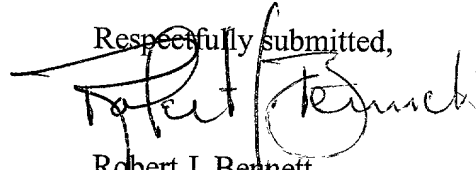
Claim 11, lines 1-2, delete "any one of claims 8, 9 and 10" and substitute therefor --claim 8--.

Claim 15, lines 1-2, delete "any one of claims 12, 13, and 14" and substitute therefor --claim 12--.

REMARKS

Amendment is made to eliminate all multiple dependencies from the claims, thereby avoiding the need to pay the multiple dependent surcharge.

Respectfully submitted,



Robert J. Bennett
Reg. No. 27,533

TOWNSEND and TOWNSEND and CREW LLP
Two Embarcadero Center, 8th Floor
San Francisco, California 94111-3834
Tel: (415) 576-0200
Fax: (415) 576-0300
RJB/tp
SF 1176575 v1

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SPECIFICATION

SAMPLE OBSERVATION METHOD AND EQUIPMENT

Technical Field

The present invention relates to sample observation method and equipment intended to be used for an automatic method of closer inspection for a defect developed or a foreign material deposited during the production of semiconductors.

Background Art

As a method of observing samples by which a foreign material or a defect can be viewed in detail, for example, the method described in JP-A-No. 09-139406 has been disclosed.

According to this method, an image pickup device such as a microscope moves to an area where a fault exists, based on the coordinates data obtained beforehand by a discrete fault inspection apparatus, and captures a defective sample image and then captures a magnified view of a foreign material or defect that is located by any means.

Although not clearly mentioned in the above-mentioned JP-A-No. 09-139406 regarding prior art, the above previous method has proved to have some drawbacks as the inventors

of the present invention examined this publication. Its drawbacks are as follows:

Judging whether defect extraction processing is successful is possible only by viewing display images that have been acquired, when there is no means for the user to check the validity of the images. If the processing is unsuccessful, we cannot know how it failed. Consequently, the setup for capturing sample images in good conditions of executing the defect extraction takes time.

After a defective sample image including a foreign material or a defect is acquired, when locating the area of the foreign material or the defect or recognizing its shape on the defective sample image with the background pattern behind it, it is desirable to capture a reference sample image not including any fault on the same background pattern together with the defective sample image and compare both images.

When closer inspection is performed by magnifying the local area of the foreign material or defect, if the defective sample image is first captured as is in the above previous method (cited as an example), the stage (platform) on which a sample is placed for inspection must be moved after the first image of the sample is captured so that the area of the reference sample image will fall within the field of view of an image pickup device. After the second image

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is captured, the exact location of the foreign material or defect is calculated and then the stage must be moved again so that the fault location will fall within the field of view of the image pickup device. Thus, the stage would move frequently to be repositioned and it would take some time to acquire the images.

If the dimensions of the field of view of the microscope when capturing a defective sample image approximate to the stage positioning error, the positioning in an area on the same background as for the defective sample image is difficult and therefore a reference sample image is difficult to acquire.

If capturing a reference sample image corresponding to a defective sample image is always performed, the number of captured images increases in proportion to the number of defects and the time required for acquiring the images increases correspondingly.

An object of the present invention is to provide sample observation method and equipment that enable faster and efficient observation of a defect, solving the problems from the drawbacks involved in prior art.

Disclosure of the Invention

In order to attain the above object, the present invention offers a method of observing samples in which a

view of a desired area of a sample is captured and the thus acquired image is displayed on a first screen, an area to be magnified and observed within the image displayed on the first screen is superimposed on the display image, a magnified view of the displayed area to be magnified and observed within the sample is captured, and the thus acquired magnified image is displayed on a second screen.

In order to attain the above object, the present invention offers a method of observing samples in which the position of a sample is adjusted so that a desired area of the sample will fall within the field of view of observation means for observation, a view of the desired area of the sample is captured at first scale factor and thus a first image is acquired, the first image is displayed on a first screen, an area to be magnified and observed within the first image displayed on the first screen is superimposed on the same screen, a view of the area to be magnified and observed is captured at second scale factor that is larger than the first scale factor and thus a second image is acquired, and the second image is displayed on a second screen.

In order to attain the above object, furthermore, the present invention offers a method of observing samples by using a scanning electron microscope, wherein the position of a sample is adjusted so that a desired area of the sample will fall within the field of view of the scanning

electron microscope for observation, a view of the desired area of the sample is captured by the scanning electron microscope at first scale factor and a first image is thus acquired, this first image is displayed on a first screen, the first image displayed on the first screen is compared with a reference sample image, an area to be magnified and observed within the first image displayed on the first screen is determined, based on the above comparison, and a magnified image of the area thus determined to be magnified and observed is displayed on a second screen.

In order to attain the above object, furthermore, the present invention offers a method of observing samples characterized by: acquiring a reference sample image not including any defect on a sample by capturing an image of the sample, based on the information on a defect developed on the sample and detected by an inspection apparatus; acquiring a defective sample image including the defect on the sample by capturing an image of the sample, based on the information on the defect developed on the sample and detected by the inspection apparatus; locating the defect on this defective sample image by comparing the reference sample image and the defective sample image; capturing a magnified view of the local area where the located defect exists on the defective sample image, thus acquiring a

magnified image of the defect; and displaying this magnified image of the defect on a screen.

In order to attain the above object, furthermore, the present invention offers a method of observing samples characterized by: acquiring a reference sample image not including any defect on a sample by capturing an image of the sample, based on the information on a defect developed on the sample and detected by an inspection apparatus; adjusting the position of the sample so that the defect will fall within the field of view of image capture, based on the information on the defect developed on the sample and detected by the inspection apparatus; acquiring a defective sample image including the defect on the sample by capturing an image of the sample in the adjusted position; locating the defect on this defective sample image by comparing the reference sample image and the defective sample image; capturing a magnified view of the local area where the located defect exists within the field of view of image capture, thus acquiring a magnified image of the defect; and displaying this magnified image of the defect on a screen.

In order to attain the above object, furthermore, the present invention offers a method of observing samples characterized by: acquiring a reference sample image not including any defect on a sample by capturing an image of the sample, based on the information on a defect developed

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on the sample and detected by an inspection apparatus; acquiring a defective sample image including the defect on the sample by capturing an image of the sample, based on the information on the defect developed on the sample and detected by the inspection apparatus; locating the defect by comparing the reference sample image and the defective sample image; capturing a magnified view of the local area where the located defect exists on the defective sample image, thus acquiring a magnified image of the defect; erasing the background from this magnified image of the defect; and displaying on a screen the magnified image of the defect from where the background has been erased.

In order to attain the above object, moreover, the present invention offers an equipment for observing samples, configured to have: image pickup means to capture a view of a sample, thus acquiring an image of the sample; storage means to receive and store data about a desired area of the sample, the view of the area to be captured by the image pickup means, from the external; position control means to control the position of the sample toward the image pickup means, based on the data about the desired area of the sample stored into the storage means; display means to display images of the sample acquired by being captured by the image pickup means; and arithmetic control means to locate a defect on the sample by comparing a plurality of

images of the sample zoomed-in by first scale factor and captured by the image pickup means after the sample is positioned by the position control means and make the display means display an image of the defect zoomed-in by second scale factor that is larger than the first scale factor, together with an image including the defect captured at the first scale factor.

In order to attain the above object, moreover, the present invention offers an equipment for observing samples, configured to have: storage means to receive and store the information on a defect developed on a sample acquired through inspection with an external defect inspection apparatus from the defect inspection apparatus; image pickup means to capture a view of the sample, thus acquiring an image of the sample; position control means to control the position of the sample, based on the information on the defect developed on the sample stored into the storage means; defect locating means to locate the defect by comparing an image of the sample not including the defect and an image of the sample including the defect, zoomed-in by first scale factor and captured by the image pickup means after the sample is positioned by the position control means, and display the image including the defect on a screen; and magnified defect display means to display a magnified image of the defect located by the defect locating

means, the image captured by the image pickup means at second scale factor that is larger than the first scale factor.

In order to attain the above object, moreover, the present invention offers an equipment for observing samples, configured to have: image pickup means to capture a view of a sample, thus acquiring an image of the sample; position control means to control the position of the sample so that a defect on the sample will fall within the field of view of the image pickup means, based on the information on the defect on the sample acquired through inspection with an external defect inspection apparatus; defect locating means to locate the defect by comparing an image of the sample not including the defect and an image of the sample including the defect, zoomed-in by first scale factor and captured by the image pickup means after the sample is positioned by the position control means, and display on a screen the image of the sample including the thus located defect; and magnified defect display means to display a magnified image of the local area of the sample corresponding to the location of the defect on the image including the defect displayed on the screen of the defect locating means, the image captured by the image pickup means at second scale factor that is larger than the first scale factor.

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By displaying a defective sample image on which the result of defect extraction processing is superimposed, the present invention enables the user to verify the validity of the defect extraction.

Processing sequence has been arranged so that the number of stage moves will decrease for more efficient image acquisition. Based on the information on the coordinates of a foreign material or defect, given in advance from a discrete inspection apparatus, a reference sample image corresponding to a defective sample image including the foreign material or defect image is initially acquired. Thereafter, the defective image of the foreign material or defect is captured.

Furthermore, the present invention captures images of samples scaled up by two different scale factors, by capturing reference and defective sample images zoomed-in by a lower scale factor, a foreign material or defect is located. A view of the local area where the located foreign material or defect exists is captured, closed up by a higher scale factor. Thereafter, the stage is moved to a position for capturing a reference sample image corresponding to the defective sample image including the foreign material or defect and the reference sample image is captured at the lower scale factor. On the reference sample image of lower scale factor, a template of the area corresponding to the

field of view set for image capture by higher scale factor is positioned. By centering the focus on the template area and closing up, a reference sample image of higher scale factor is captured. In this way, the present invention makes it possible that a reference sample image of higher scale factor corresponding to a defective sample image of higher scale factor be acquired.

Acquired reference sample images are recorded in such a manner that a reference sample image and its area set for image capture, based on the system of coordinates on a chip, assigned for each individual chip, are recorded in a set. When another defect is inspected, if the area for capturing its reference sample image, expressed by coordinates on a chip, is found in the recorded areas of the acquired images, the recorded image is used instead of acquiring the reference sample image. By applying the present invention in this way, the efficiency of image acquisition and inspection would further increase.

Brief Description of Drawings

Fig. 1 is a front view of sample observation equipment according to the present invention, showing its structure in outline.

Fig. 2 is a flowchart illustrating a sample observation procedure according to the present invention

and Fig. 3 shows the sample images acquired by the sample observation procedure of the present invention.

Fig. 4 is a flowchart a flowchart illustrating a sample observation procedure according to the present invention and Fig. 5, Fig. 6, and Fig. 7 show the sample images acquired by the sample observation procedure of the present invention.

Fig. 8 is a flowchart a flowchart illustrating a sample observation procedure according to the present invention and Fig. 9, Fig. 10, and Fig. 11 show the sample images acquired by the sample observation procedure of the present invention.

Fig. 12 is a flowchart illustrating a sample observation procedure according to the present invention.

Fig. 13 and Fig. 14 show the locations of defects on a wafer and a map of reference sample images, respectively.

Fig. 15 is a block diagram showing an image data acquisition system configuration in outline according to the invention.

Best Mode for Carrying Out the Invention

Using the drawings for reference, how the prevent invention is embodied will be explained below.

Fig. 1 shows one mode of configuring an image acquisition equipment for carrying out closer defect inspection according to the present invention.

In Fig. 1, reference number 1 is a semiconductor wafer that is subjected to inspection and this wafer is fixed to an X-Y stage 2. The X-Y stage 2 can move in X and Y directions in response to control signals sent from a computer 3 via a controller 4.

Reference number 5 is an image pickup device using a scanning electron microscope (hereinafter referred to as SEM) and this image pickup device captures a magnified view of the semiconductor wafer 1. Specifically, electron beams 502 emitted from an electron source 501 are focused through an electro-optic complex 503 on the semiconductor wafer 1 that is a sample and the wafer 1 is scanned with the beams 502. Secondary electrons reflected from the semiconductor wafer 1 irradiated with the electron beams 502 are detected by a detector 504. In this way, an image of the semiconductor wafer 1 is captured through the SEM.

The image pickup device 5 enables close observation of surface condition anywhere on the semiconductor wafer 1 by controlling the X-Y stage 2. An image captured by the image pickup device 5 is input to the computer 3 and subjected to processing such as defect extraction. The result of processing is displayed on a monitor 7 via a

display-switching device 6. The computer 3 may undertake the task of the display-switching device 6.

Fig. 2 illustrates an example of the procedure for acquiring images of a sample under inspection and Fig. 3 shows example images acquired by the procedure in Fig. 2.

It is assumed that a semiconductor wafer that is subjected to close inspection has been inspected in advance by a surface defect inspection apparatus which is not shown such as a foreign material inspection apparatus or an appearance inspection apparatus and the coordinates data on the location of a foreign material or a defect has been acquired.

First, the semiconductor wafer 1 to be further inspected is loaded on the X-Y stage 2 and the system of coordinates on the X-Y stage 2 and the system of coordinates on the semiconductor wafer 1 are calibrated by using the semiconductor design data or the acquired defect location data.

Then, the computer 3 sends a command to drive the X-Y stage to the controller 4, based on the defect location coordinates data of the semiconductor wafer 1 stored in advance into the computer 3 at the time of receiving the result of inspection with a surface defect inspection apparatus which is not shown. When receiving this command, the controller 4 drives the X-Y stage 2. In response to the

At this time, the position on which the image pickup must focus is not limited to the above position on the adjacent chip, but may be set in the corresponding coordinates on the system of coordinates of another chip, a few chips apart from the chip where the defect exists. Furthermore, the focus position may be set on a chip having the corresponding pattern of the chip where the defect exists, instead of being set in the corresponding coordinates on the chip.

Next, the controller 4 repositions the stage 2 so that the defect detected by the surface inspection apparatus

will fall within the field of view of the image pickup device 5 set at the first scale factor. The image pickup device 5 captures a view of the chip including the defect, thereby acquiring an image 9 that is a defective sample image.

Then, the acquired image 9 is laid on top of the acquired image 8 with exact alignment by using template matching and a defect location 10 on the defective sample image is calculated by detecting an area of difference between both images.

Next, the scale factor of image pickup is set at a second scale factor that is larger than the first scale factor and the area to be scanned with electron beams is adjusted so that the defect location 10 will be centered in the area. The image pickup device 5 captures a view of this area, thereby acquiring an image 11 that is a defective sample image 2 captured at a higher scale factor with the defect location 10 being in the center of the image.

Possible methods of setting the second scale factor of image pickup are as follows: set a desirable scale factor while monitoring the image displayed on the monitor 7 as the area to be scanned with electron beams is narrowed or define the area to be scanned with electron beams in advance by drawing with a cursor or a light pen on the screen of the monitor 7.

By thus acquiring the defective sample image of higher scale factor, any foreign material or defect existing there can be inspected more closely for its shape, surface condition, etc.

In the above process, the defect is located on the sample image captured at the first scale factor after the object position is set so that the defect will fall within the field of view of the image pickup and the scan area of SEM is focused on the located defect position and its surrounding area, assuring that the image of higher scale factor can be acquired. Thus, the image pickup device 5 can surely capture the view of the foreign material or defect within its field of view when capturing the image of higher scale factor.

Because the image 9 is captured after the image 8 is captured in the above procedure, it is not necessary to move the stage 2 after the calculation of the defect location 10 before the image 11 is acquired. Thus, the defective sample image of higher scale factor can be acquired efficiently.

During this process, the area of difference between the image 8 and the image 9 is superimposed on the image 9 displayed on the monitor, so that the user can know how the local area where the defect exists has been determined for extraction.

On the sample image of lower scale factor, the area to be observed at higher scale factor within the displayed image is superimposed thereon or simultaneously displayed while this image is displayed. In other words, the field of view 12 of image pickup at the higher scale factor with the defect location 10 in its center is superimposed on the image 9 displayed or simultaneously displayed with the image 9 displayed on the monitor 7. In this way, the user can be visually informed that what area is extracted and its view is captured as the defective sample image of the higher scale factor.

Furthermore, two or more images of image 8, image 9, image 9 on which the local area of defect or the field of view 12 of image pickup at the higher scale factor is superimposed, and image 9 may be simultaneously displayed on the monitor or monitors 7, so that the user can acquire images while checking the image acquisition operation. A plurality of monitors 7 may be provided on which the images 8, 9, and 11 may be displayed separately or some of them in combination. Alternatively, multiple images may be displayed simultaneously or alternately on one monitor.

The images 8 and 9 may be produced as patterns that are not exactly matching due to the error of positioning the stage 2. In that event, in the process of detecting differential area by laying one image on top of the other

image, only the portion of the area that is positively included in both images is effective. The field of view 12 where the image of the object can be captured at the higher scale factor must fall within the field of view for capturing the image 9. That is, the first scale factor and the second scale factor must be correlated to each other. Thus, after the user specifies either the first or second scale factor, the remaining scale factor setting should be restricted within a range.

The background of the image 11 can be erased and only the portion of the defect can be extracted such that automatic inspection is carried out in the local area where the foreign material or defect exists. The procedure for this processing is shown in Fig. 4 and example images acquired by this procedure of defect extraction processing are shown in Fig. 5.

In the same way as in the procedure example shown in Fig. 2, the images 8, 9, and 11 are acquired sequentially. In a differential image 13 that represents the area of difference between the image 8 and the image 9, an area 12 that corresponds to the field of view for capturing a defective sample image 2 in a defective sample image 1 is magnified by image processing by the same scale factor as for the defective sample image 2, and a mask image 14 is thus created.

Next, by laying this mask image 14 on top of the image 14, an area corresponding to the difference between the image 11 and the mask image 14 is extracted. By erasing the differential area from the image 11, the background is erased from the image 11 and an image 15 where only the extracted area of the defect remains can be acquired.

By detecting characteristic shape, brightness, texture, etc. of the defect in this extracted area, the analysis of the defect can be performed without intervention of a person.

Another method of erasing the background from the image 11 may be used as shown in Fig. 6. In an image 8 that is a reference sample image, an area with the same background as for the focus area 12 for capturing the image 11 in an image 9 that is a defect sample image 1 is magnified by image processing by the same scale factor as for the image 11 and a magnified reference sample image 16 is thus created. Then, the difference between the image 11 and image 16 is extracted.

An alternative to the above method may be used as shown in Fig. 7. After the image 11 is captured, a reference target is selected from the chips adjacent to the defect area, within the periphery of a few chips apart from the defect area, or among the areas with the same pattern that the image 11 has. The stage 2 is moved for repositioning

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so that the target will fall within the field of view of the image pickup device 5. A view of the target is captured by the image pickup device 5 at the same scale factor as for the image 11 and thereby an image 17 that is a reference sample image 2 is acquired. Then, the difference between the image 11 and the image 17 is extracted.

If the size of the field of view for capturing the image 11 approximates to the precision range of moving the stage 2, when the image 17 is captured after the stage 2 is repositioned as in the example shown in Fig. 7, the position of capturing the image may become off the desired position.

In that event, a reference sample image that exactly matches the image 11 can be acquired in the example procedure shown in Fig. 8. Fig. 9 shows example images acquired by the procedure shown in Fig. 8.

As shown in Fig. 3, correspondingly, the images 8, 9, and 11 are acquired sequentially.

Then, the stage 2 is moved to the position in which the image 8 has been captured and an image 18 that is a reference sample image 2 is captured at the same scale factor as for the image 8.

At this time, the image 8 and the image 18 are not matching in alignment because of the error of positioning the stage 2.

Then, an area on the image 8, corresponding to the focus area 12 in the image 11, is cut out of the image 8 as a template. The template is positioned in the matching position on the image 18.

The template is placed so that its center exactly matches the center of the area where the pattern corresponds to the background of the image 11.

Focusing on the area on which the template is placed, the image pickup device captures an image 19 that is a reference sample image 3 at the same scale factor as for the image 11.

By using the above image capturing sequence, the image 19 corresponding to the image 11 can be captured surely even if the size of the field of view for capturing the image 11 approximates to the precision range of moving the stage 2.

In this image capturing sequence, means for increasing the allowance for the area of the image 18 to include the focus area for capturing the image 19 may be used as follows. An offset of the defect location 10 in the image 9 from the center of the image 9 is recorded in advance. When the stage 2 is moved to be repositioned for capturing the image 18, the distance over which the stage 2 moves is adjusted by the offset so that the position corresponding to the defect location will be centered in the image 18.

When capturing images, it is advisable to adjust the brightness and contrast controls so that a couple of images zoomed-in by same scale factor, such as the images 8 and 9, the images 18 and 9, and the images 11 and 19 will have the same brightness and contrast.

The above image capturing sequence may be altered as follows. Initially, the image 9 that is a defect sample image 1 is captured, zoomed-in by the first scale factor. After the stage 2 is moved to be repositioned, the image 8 is captured as a reference sample image 1. After calculating the coordinates of the defect location 10 from the images 8 and 9, the image 19 is captured, zoomed-in by a higher second scale factor, and a reference sample image 3 is thus acquired. The stage 2 is moved to the defect location and an image is captured at the first scale factor and the image corresponding to the defective sample image 1 is acquired. After calculating the coordinates of the defect location in the center of the field of view for capturing a defective sample image zoomed-in by the higher scale factor, the image 11 is captured at the second scale factor as a defective sample image 2.

With Fig. 10, the following discusses a case where a plurality of defects are serially inspected by the method of the present invention in the procedure explained with

Figs. 2 and 3, where a reference sample image of higher scale factor is not used.

In this case, by repeating the step of capturing a reference sample image in the processing sequence described in Figs. 2 and 3, where a reference target is selected from the chips adjacent to the defect area or within the periphery of a few chips apart from the defect area, images 8 for all defects to be inspected are serially captured. Then, the steps of moving the X-Y table 2 for repositioning so that the defect area will fall within the field of view of the image pickup device 5, capturing a view of the defect area zoomed-in by a first scale factor and thus acquiring an image 9, calculating the coordinates of the defect location 10, and capturing a view of the defect zoomed-in by a second scale factor and thus acquiring an image 11 are carried out serially for all the plurality of defects. By capturing the images in this way, efficient image acquisition can be performed with the reduced number of stage moves.

With Fig. 11, the following discusses a case where a plurality of defects are serially inspected by the method of the present invention, which includes the step acquiring reference sample images of higher scale factor.

By selecting a reference target from the chips adjacent to the defect area or within the periphery of a few chips apart from the defect area, first, images 8 for all

defects to be inspected are serially captured as reference sample images 1. Then, the operations of moving the X-Y table 2 for repositioning so that the defect area will fall within the field of view of the image pickup device 5, capturing an image 9 of the defect area zoomed-in by a first scale factor, calculating the coordinates of the defect location 10, and capturing an image 11 of the defect are carried out serially and repeated for all the defects.

Next, the following are carried out serially and repeated for all the defects: moving the stage 2 to the position in which the image 8 has been acquired; capturing an image 18 at the same scale factor as for the image 8; cutting a template of the area corresponding to the focus area 12 in the image 9 out of the image 8; positioning the template in the matching position on the image 18; focusing on the area on which the template is placed; and capturing an image 19 at the same scale factor as for the image 11.

When capturing the image 18, however, the stage 2 is not always moved to the position in which the image 8 has been acquired. The stage 2 may be repositioned to any chip that has the same pattern as the background pattern of the image 9.

As another example of implementing the present invention, Figs. 12 and 13 illustrates the procedure for

reducing the number of times of acquiring a reference sample image in the processing example shown in Figs. 2 and 3.

As images 8 are acquired, according to the method described for the processing example shown in Figs. 2 and 3, a map of the acquired reference sample images is created. In this map, an individual image 8 is recorded, and moreover, the field of view for capturing the image 8, or in other words, the focus area described in terms of the system of coordinates on a chip, defined for each individual chip, is recorded.

When the coordinates of another defect to be inspected more closely are acquired from another inspection apparatus, determination is made as to whether a reference area corresponding to the local area of the defect detected by the coordinates data is found in the areas stored in the map of the reference sample images. If the same area is found in the map, the required area data is retrieved from the image data recorded in the map and used as the image 8 instead of capturing the image 8.

This map of reference sample images may be created to contain the reference sample images zoomed-in by first scale factor or the images zoomed-in by second scale factor, captured at a higher scale factor.

By thus recording acquired reference sample images and reusing them, the number of times of acquiring a

reference sample image can be reduced. Particularly, if all reference sample images of required areas are recorded in the map of reference sample images, it is not necessary to execute the reference sample image acquisition step, and consequently the time of image acquisition and closer inspection can be reduced considerably.

As shown in Fig. 14, in the map of reference sample images, not only an area in which a reference sample image has been captured is recorded, but also an area with the same pattern that an acquired reference sample image has may be recorded as the acquired reference sample image area.

In, for example, an area of iterative pattern, if an image of iterative pattern of one cycle or more is acquired, a reference sample image in any area in the iterative pattern area can be created by combining some portions of the acquired iterative pattern image. Thus, acquiring an image of an iterative pattern area is equivalent to acquiring all reference sample images in the area.

By thus recording a comprehensive area equivalent to acquired reference sample images as acquired area in the map of reference sample images, the number of reference sample images acquired can be decreased, and consequently the time required for closer inspection can be reduced.

Alternatively, views of all chip areas may be acquired in advance as reference sample images.

Alternatively, mapping of all sample reference images may be programmed as follows: once a predetermined number of defects have been inspected and a map of reference sample images thereof has been created, views of areas for which reference sample images have not been captured are serially captured as reference sample images.

By programming in this way, when the predetermined number of defects have been inspected, it is assured that all reference sample images are acquired. Therefore, the user can refer to reliable information about the time required for further defect inspection after the completion of inspecting the predetermined number of defects.

Fig. 15 shows an example configuration for such operation that reference sample image data and the map of reference sample images acquired by the method described above are shared with a plurality of units of image acquisition equipment.

In this configuration, a plurality of units of image acquisition equipment 20 and a server 21 (hereinafter referred to as a database 21) are interconnected via a network. Each image acquisition equipment 20 sends reference sample image data and captured image area data in the map of reference sample images to the database 21. The

database 21 has an integrated map of reference sample images into which the reference sample image data sent from the image acquisition equipment 20 is stored.

When each image acquisition equipment 20 executes the inspection of a defect, the equipment searches the map of reference sample images on the database 21 to determine whether a reference sample image corresponding to the defect area has been acquired. If the reference sample image has not been acquired, the image acquisition equipment executes the reference sample image acquisition processing as explained above and sends the acquired reference sample image data to the database 21. If the reference sample image has been acquired, the image acquisition equipment retrieves the appropriate data of the reference sample image from the database 21 and executes closer inspection by using this data.

By using the shared database in this way, reference sample images can be acquired more efficiently. Consequently, the time for closer inspection can be reduced by sharing the reference sample image data.

A single unit of image acquisition equipment may be used to acquire reference sample images.

According to the present invention, as explained above, the user can check to see whether defect extraction processing is successful and know the relation between two

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scale factors. Therefore, the user can easily perform the setup of image capturing conditions for easy defect extraction and scale factor settings.

The invention can reduce the number of stage moves, which means that defective and reference sample images can be captured efficiently; that is, the image acquisition time can be reduced.

When capturing images of samples closed up by a higher scale factor, which is the process on which the error of positioning the stage has some influence, the present invention enables stable acquisition of defective and reference sample images, so that closer defect inspection can be executed in stable condition.

According to the present invention, a defective sample image is displayed on which the result of defect extraction processing is superimposed, and therefore the user can verify the validity of the defect extraction.

Based on the information on the coordinates of a foreign material or defect, given in advance from a discrete inspection apparatus, a reference sample image corresponding to a defective sample image including the foreign material or defect image is initially acquired. Thereafter, the defective image of the foreign material or defect is captured. Thus, the number of stage moves is fewer and more efficient image acquisition can be achieved.

According to the present invention, furthermore, images of samples are captured, scaled up by two different scale factors, By capturing reference and defective sample images zoomed-in by a lower scale factor, a foreign material or defect is located. A view of the local area where the located foreign material or defect exists is captured, closed up by a higher scale factor. Thereafter, the stage is moved to a position for capturing a reference sample image corresponding to the defective sample image including the foreign material or defect and the reference sample image is captured at the lower scale factor. On the reference sample image of lower scale factor, a template of the area corresponding to the field of view set for image capture by higher scale factor is positioned. By centering the focus on the template area and closing up, a reference sample image of higher scale factor is captured. In this way, the present invention makes it possible that a reference sample image of higher scale factor corresponding to a defective sample image of higher scale factor be acquired.

Reference sample images acquired in the method of present invention are recorded in such a manner that a reference sample image and its area set for image capture, based on the system of coordinates on a chip, assigned for each individual chip, are recorded in a set. When another defect is inspected, if the area for capturing its reference

sample image, expressed by coordinates on a chip, is found in the recorded areas of the acquired images, the recorded image is used instead of acquiring the reference sample image. Therefore, the present invention further increases the efficiency of image acquisition and inspection.

Industrial Applicability

According to the present invention, as explained above, a foreign material or defect is located by capturing reference and defective sample images zoomed-in by a lower scale factor and a view of the local area where the located foreign material or defect exists is captured, closed up by a higher scale factor. Thereafter, the stage is moved to a position for capturing a reference sample image corresponding to the defective sample image including the foreign material or defect and the reference sample image is captured at the lower scale factor. On the reference sample image of lower scale factor, a template of the area corresponding to the field of view set for image capture by higher scale factor is positioned. By centering the focus on the template area and closing up, a reference sample image of higher scale factor is captured. In this way, a reference sample image of higher scale factor corresponding to a defective sample image of higher scale factor can be acquired. The present invention is suitable for being used

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as an automatic method of closer inspection for a defect developed or a foreign material deposited during semiconductor production process.

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Claims

1. Sample observation method intended for observing samples, characterized by:

capturing a view of a desired area of a sample by image pickup means and displaying the thus acquired image on a first screen;

prompting the operator to select an area anywhere on the image, the area to be magnified and observed within the image displayed on the screen;

capturing a view of the selected area of the sample to be magnified and observed, by the image pickup means, and acquiring a magnified image of the view; and

displaying the magnified image on a second screen.

2. Sample observation method intended for observing samples, characterized by:

adjusting the position of a sample so that a desired area of the sample will fall within the field of view of the image pickup means;

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        capturing a view of the desired area of the sample
zoomed-in by first scale factor, thus acquiring a first
image;

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displaying the first image on a first screen;
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superimposing an area to be magnified and observed within the first image displayed on the first screen on the screen;

capturing a view of the area to be magnified and observed, by the image pickup means, at second scale factor that is larger than the first scale factor, thus acquiring a second image; and

displaying the second image on a second screen.

3. Sample observation method according to claim 1 or 2, characterized in that the image pickup means is a scanning electron microscope.

4. Sample observation method intended for observing samples by using a scanning electron microscope, characterized by:

adjusting the position of a sample so that a desired area of the sample will fall within the field of view of the scanning electron microscope;

capturing a view of the desired area of the sample by the scanning electron microscope at first scale factor, thus acquiring a first image;

displaying the first image on a first screen;

comparing the first image displayed on the first screen with a reference sample image;

determining an area to be magnified and observed in the first image displayed on the first screen, based on the above comparison; and

displaying on a second screen a magnified image of the area thus determined to be magnified and observed.

5. Sample observation method according to any one of claims 1, 2, 3, and 4, characterized in that the desired area of the sample is an area including a defect on the sample that has been detected by inspection with a surface defect inspection apparatus.

6. Sample observation method according to any one of claims 1, 2, 3, and 4, characterized in that the first screen and the second screen appear on different display screens.

7. Sample observation method according to any one of claims 1, 2, 3, and 4, characterized in that the first screen and the second screen appear on a same display screen.

8. Sample observation method characterized by:

acquiring a reference sample image not including any defect on a sample by capturing an image of the sample, based on the information on a defect developed on the sample and detected by an inspection apparatus;

acquiring a defective sample image including the defect on the sample by capturing a image of the sample, based on the information on the defect developed on the sample and detected by the inspection apparatus

locating the defect on the defective sample image by comparing the reference sample image and the defective sample image;

capturing a magnified view of the local area where the located defect exists within the area whose view has been captured as the defective sample image, thus acquiring a magnified image of the defect; and

displaying the magnified image of the defect on a screen.

9. Sample observation method characterized by:

acquiring a reference sample image not including any defect on a sample by capturing an image of the sample, based on the information on a defect developed on the sample and detected by an inspection apparatus;

adjusting the position of the sample so that the defect will fall within the field of view of image capture, based on the information on the defect developed on the sample and detected by the inspection apparatus;

acquiring a defective sample image including the defect on the sample by capturing an image of the sample in the adjusted position;

locating the defect on the defective sample image by comparing the reference sample image and the defective sample image;

capturing a magnified view of the local area where the located defect exists within the field view of image capture, thus acquiring a magnified image of the defect; and

displaying the magnified image of the defect on a screen.

10. Sample observation method characterized by:

acquiring a reference sample image not including any defect on a sample by capturing an image of the sample, based on the information on a defect developed on the sample and detected by an inspection apparatus;

acquiring a defective sample image including the defect on the sample by capturing an image of the sample, based on the information on the defect developed on the sample and detected by the inspection apparatus

locating the defect on the defective sample image by comparing the reference sample image and the defective sample image;

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position control means to control the position of the sample toward the image pickup means, based on the data

about the desired area of the sample stored into the storage means;

display means to display images of the sample acquired by being captured by the image pickup means; and

arithmetic control means to locate a defect on the sample by comparing a plurality of images of the sample zoomed-in by first scale factor and captured by the image pickup means after the sample is positioned by the position control means and make the display means display an image of the defect zoomed-in by second scale factor that is larger than the first scale factor, together with an image including the defect captured at the first scale factor.

13. Sample observation equipment intended for observing samples, characterized by comprising:

storage means to receive and store the information on a defect developed on a sample acquired through inspection with an external defect inspection apparatus from the defect inspection apparatus;

image pickup means to capture a view of the sample, thus acquiring an image of the sample;

position control means to control the position of the sample, based on the information on the defect developed on the sample stored into the storage means;

magnified defect display means to display a magnified image of the defect located by the defect locating means, the image captured by the image pickup means at second scale factor that is larger than the first scale factor.

image pickup means to capture a view of a sample,
thus acquiring an image of the sample;

defect locating means to locate the defect by comparing an image of the sample not including the defect and an image of the sample including the defect, zoomed-in by first scale factor and captured by the image pickup

means after the sample is positioned by the position control means, and display on a screen the image of the sample including the defect thus located; and

magnified defect display means to display a magnified image of a local area of the sample corresponding to the location of the defect on the image of the sample including the defect displayed on the screen of the defect locating means, the image captured by the image pickup means at second scale factor that is larger than the first scale factor.

15. Sample observation equipment according to any one of claims 12, 13, and 14; characterized in that the image pickup means is a scanning electron microscope.

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TOP SECRET

Abstract

During closer inspection with a local defect area being magnified, it is desirable to reduce image acquisition time by making the number of stage moves as few as possible so that a defect can be observed efficiently. To accomplish this, the invention offers a method of observing samples characterized by: acquiring a reference sample image not including any defect on a sample by capturing an image of the sample, based on the information on the defect developed on the sample and detected by an inspection apparatus; adjusting the position of the sample so that the defect will fall within the field of view of image capture, based on the above information; acquiring a defective sample image including the defect on the sample by capturing an image of the sample in the adjusted position; locating the defect on the defective sample image by comparing the reference sample image and the defective sample image; acquiring a magnified image of the defect by capturing a magnified view of the local area where the located defect exists within the field of view of image capture; and displaying the magnified image of the defect on a screen.

TOP SECRET

FIG.1

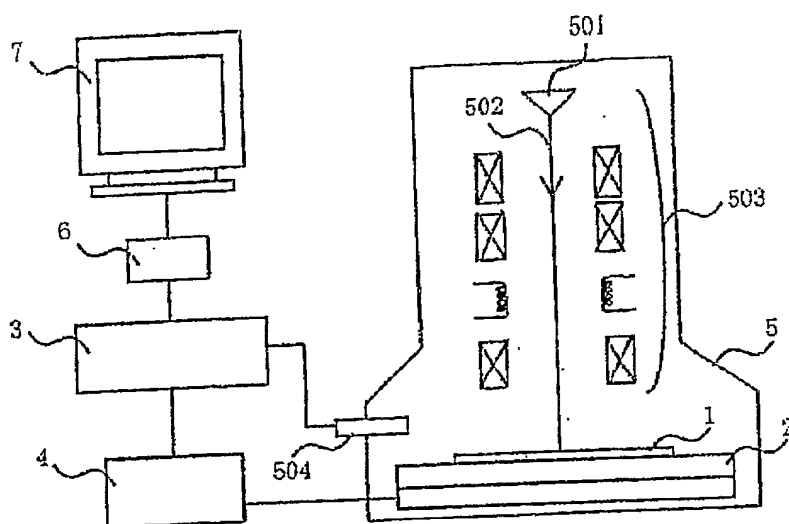


FIG.2

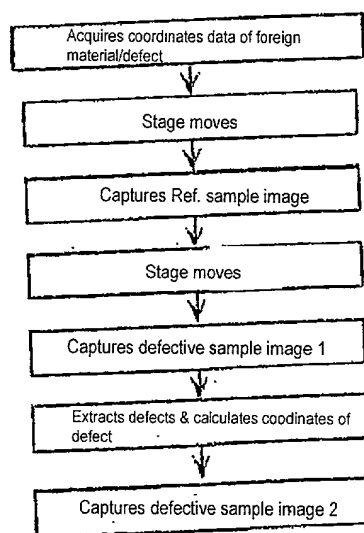


FIG.3

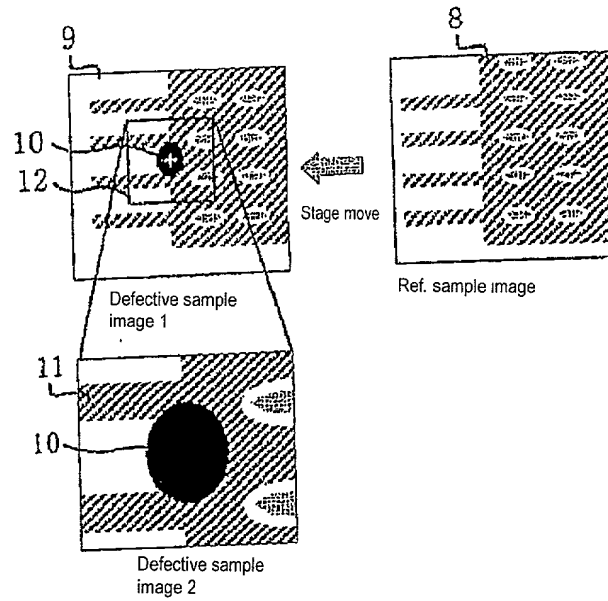


FIG.4

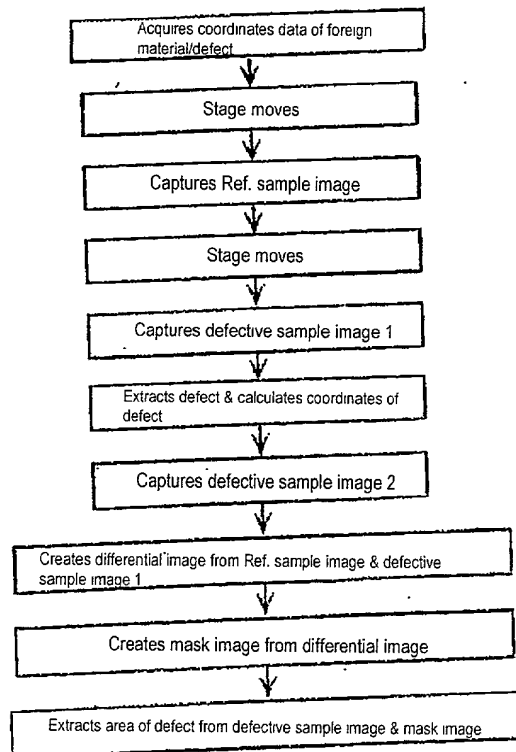


FIG. 5

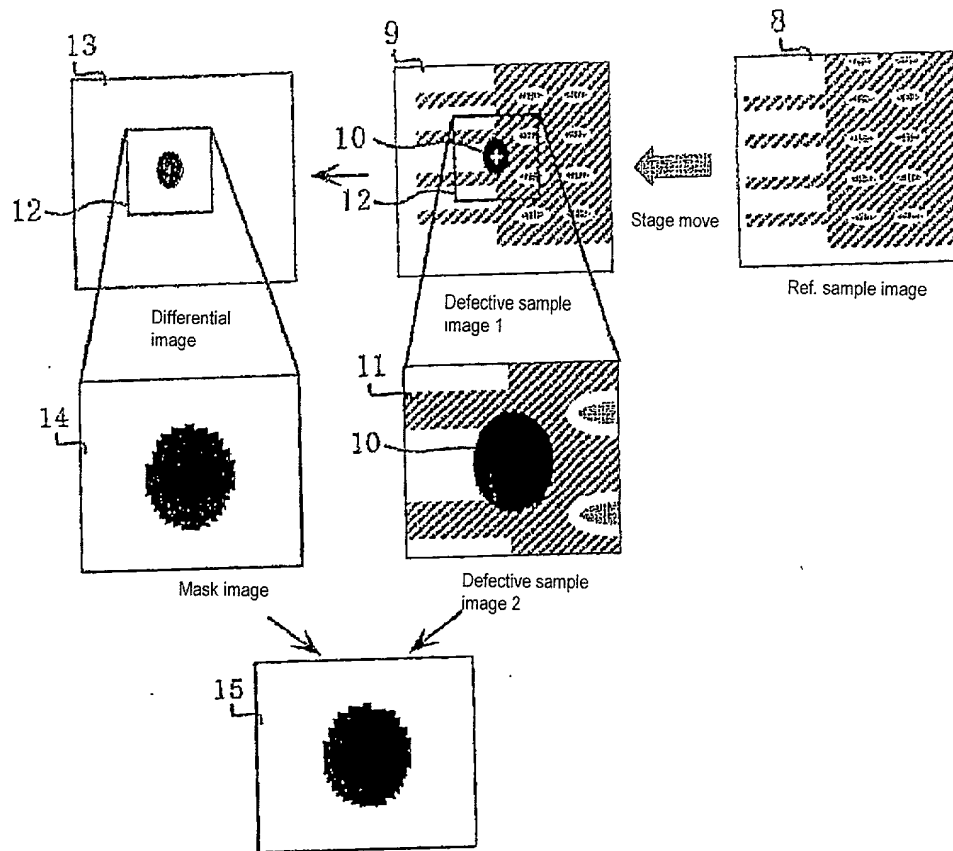


FIG. 6

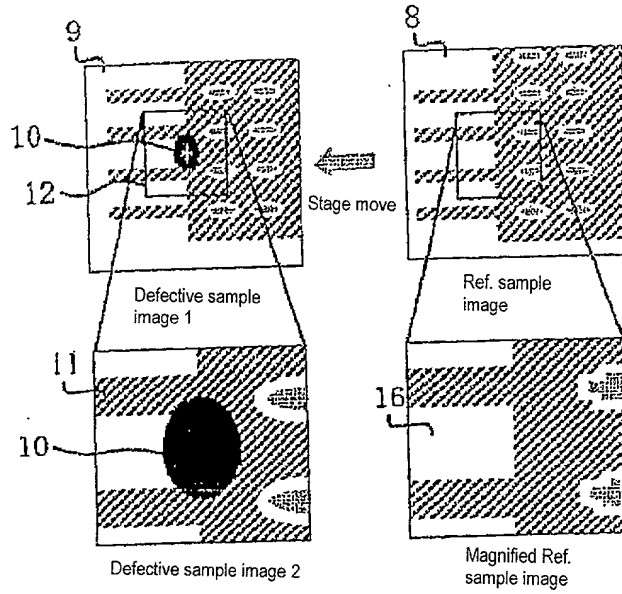


FIG. 7

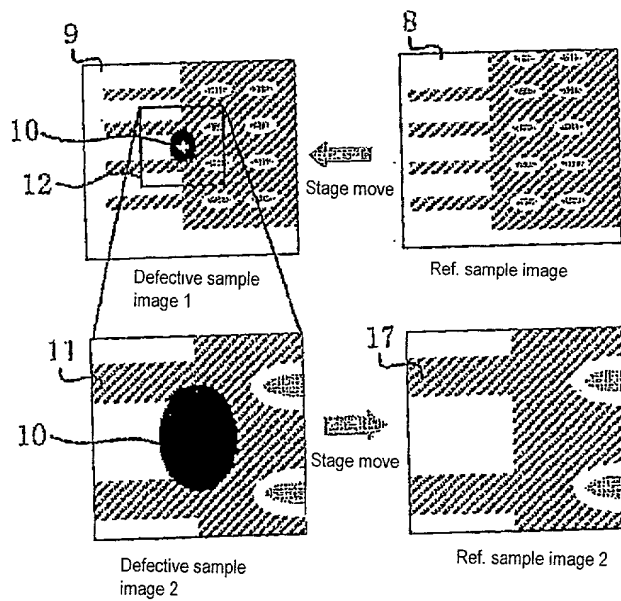


FIG.8

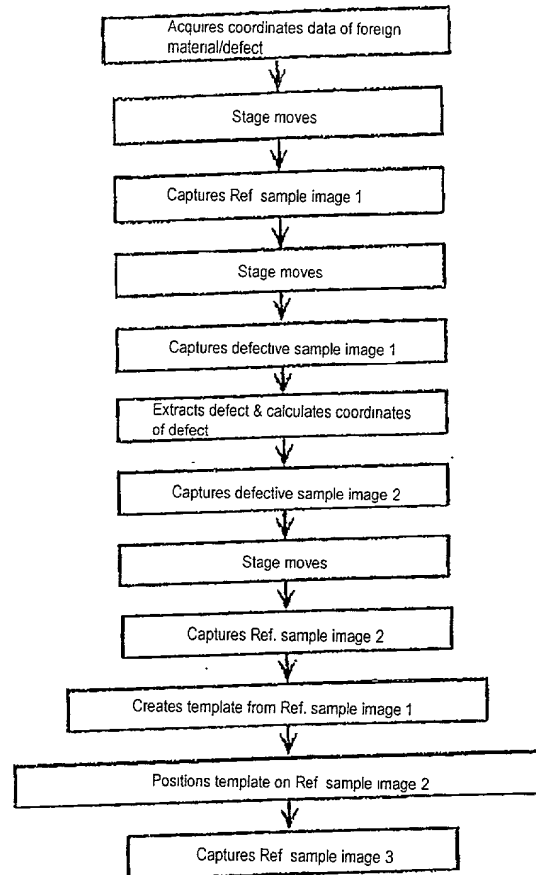


FIG.9

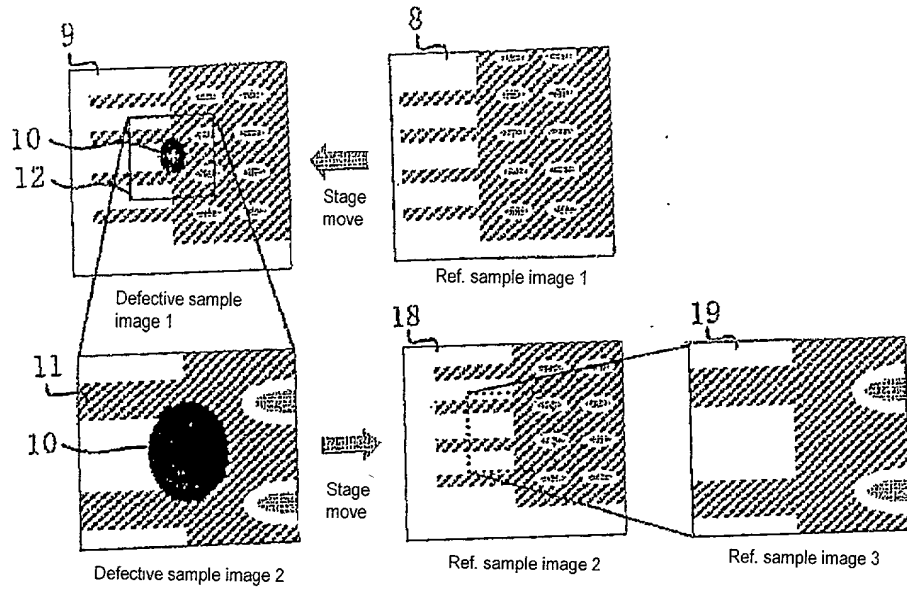


FIG.10

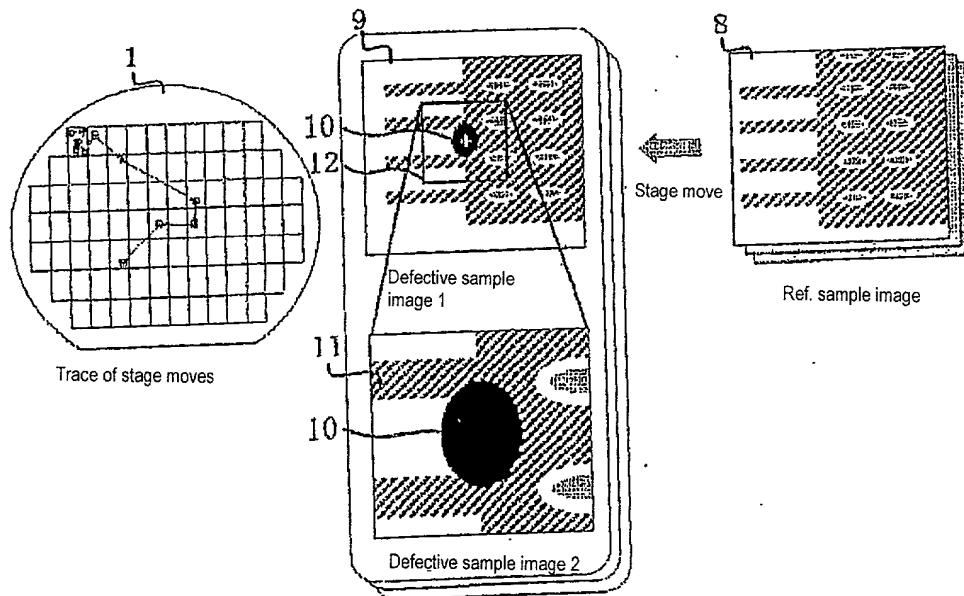


FIG.11

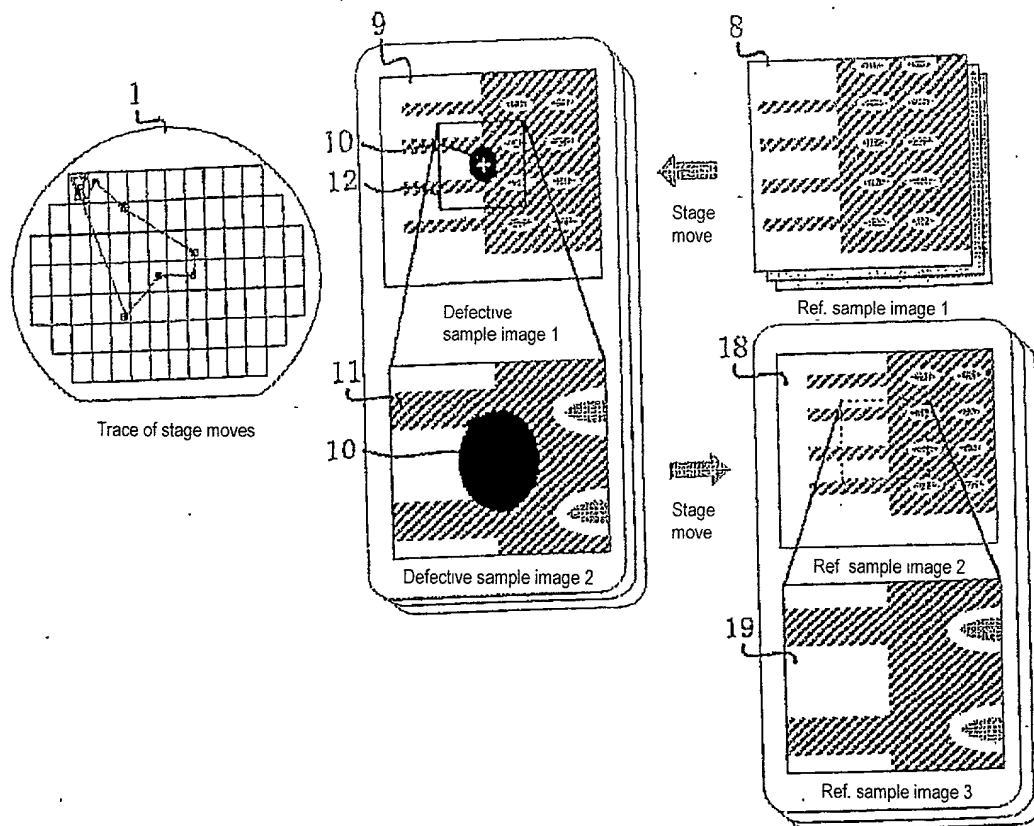


FIG.12

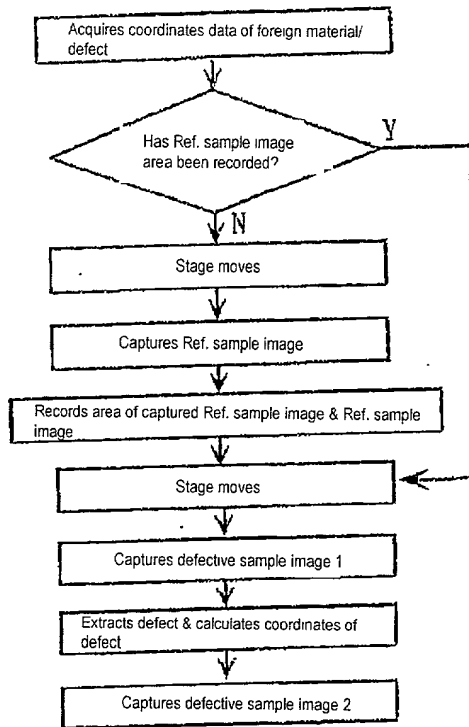


Fig.13

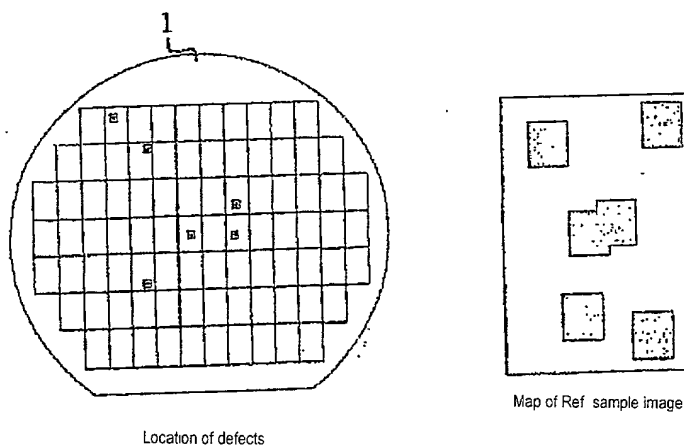


FIG.14

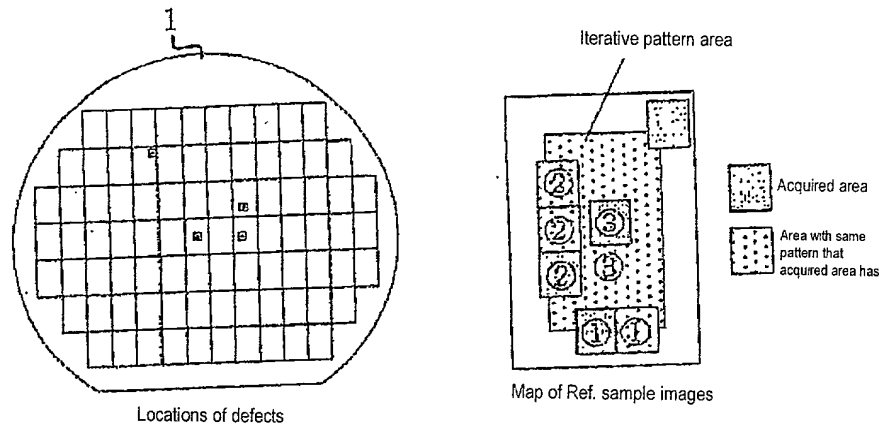
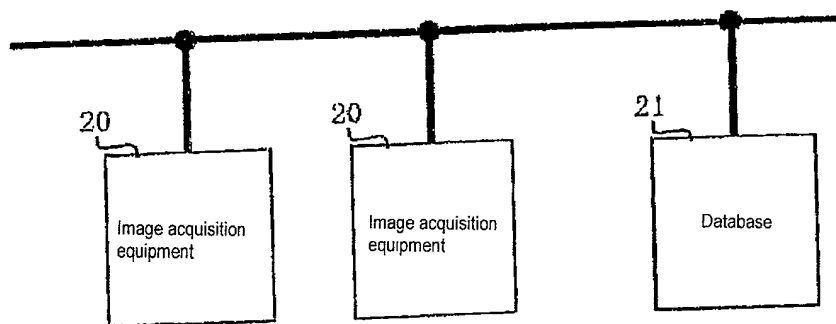


FIG.15



Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

SAMPLE OBSERVATION METHOD AND EQUIPMENT

上記発明の明細書（下記の欄で×印がついていない場合は、本書に添付）は、

The specification of which is attached hereto unless the following box is checked:

☐ 月 日に提出され、米国出願番号または特許協定条約国際出願番号を _____ とし、
(該当する場合) _____ に訂正されました。

☐ was filed on _____
as United States Application Number or
PCT International Application Number
PCT/JP99/03620 and was amended on
5/July/1999 (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Japanese Language Declaration (日本語宣言書)

私は、米国法典第35編119条 (a) - (d) 項又は365条 (b) 項に基づき下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約365 (a) 項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示している。

Prior Foreign Application(s)

外国での先行出願

10-195345	Japan
(Number)	(Country)
(番号)	(国名)
(Number)	(Country)
(番号)	(国名)

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Priority Not Claimed

優先権主張なし

10/July/1998	<input type="checkbox"/>
(Day/Month/Year Filed)	
(出願年月日)	
(Day/Month/Year Filed)	<input type="checkbox"/>
(出願年月日)	

私は、第35編米国法典119条 (e) 項に基づいて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.)	(Filing Date)
(出願番号)	(出願日)

私は、下記の米国法典第35編120条に基づいて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条 (c) に基づく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of application.

(Application No.)	(Filing Date)
(出願番号)	(出願日)

(Status: Patented, Pending, Abandoned)
(現況: 特許許可済、係属中、放棄済)

(Application No.)	(Filing Date)
(出願番号)	(出願日)

(Status: Patented, Pending, Abandoned)
(現況: 特許許可済、係属中、放棄済)

私は、私自身の知識に基づいて本宣言書で私が行なう表明が真実であり、かつ私の入手した情報と私の信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Japanese Language Declaration
(日本語宣言書)

委任状: 私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。(弁護士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith (list name and registration number)

Robert C. Colwell, Reg. No. 27,431; William L. Shaffer, Reg. No. 37,234; Paul A. Durdik, Reg. No. 37,819; Kim Kanzaki, Reg. No. 37,652 and George B.F. Yee, Reg. No. 37,478

書類送付先

Send Correspondence to:

Robert C. Colwell

TOWNSEND and TOWNSEND and CREW LLP

Two Embarcadero Center, 8th Floor

San Francisco, California 94111-3834

直接電話連絡先: (氏名及び電話番号)

Direct Telephone Calls to: (name and telephone number)

Telephone: (650)326-2400

Fax: (650)326-2422

唯一または第一発明者	1-00	Full name of sole or first inventor	Kenji OBARA
発明者の署名	日付	Inventor's signature	Date
		Kenji Obara	Oct. 16, 2000
住所		Residence	
		Yokohama, Japan	JPL
国籍		Citizenship	
		Japan	
私書箱		Post Office Address	
		c/o Hitachi, Ltd., Intellectual Property Group	
		New Marunouchi Bldg. 5-1, Marunouchi 1-chome,	
		Chiyoda-ku, Tokyo 100-8220, Japan	

(第二以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for second and subsequent joint inventors.)

第二共同発明者	2-00	Full name of second joint inventor, if any Yuji TAKAGI
第二共同発明者の署名	日付	Second inventor's signature Date <i>Yuji Takagi</i> Oct. 16, 2000
住所		Residence Yokohama, Japan JPX
国籍		Citizenship Japan
私書箱		Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第三共同発明者	3-00	Full name of third joint inventor, if any Atsushi SHIMODA
第三共同発明者の署名	日付	Third inventor's signature Date <i>Atsushi Shimoda</i> Oct. 16, 2000
住所		Residence Yokohama, Japan JPX
国籍		Citizenship Japan
私書箱		Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第四共同発明者	4-00	Full name of fourth joint inventor, if any Ryou NAKAGAKI
第四共同発明者の署名	日付	Fourth inventor's signature Date <i>Ryo Nakagaki</i> Oct. 21, 2000
住所		Residence Yokohama, Japan JPX
国籍		Citizenship Japan
私書箱		Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第五共同発明者	5-00	Full name of fifth joint inventor, if any Seiji ISOGAI
第五共同発明者の署名	日付	Fifth inventor's signature Date <i>Seiji Isogai</i> Nov. 1, 2000
住所		Residence Hitachinaka, Japan JPX
国籍		Citizenship Japan
私書箱		Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan

(第六以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for sixth and subsequent joint inventors.)

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第六共同発明者	6-00	Full name of sixth joint inventor, if any Yasuhiko OZAWA
第六共同発明者の署名	日付	Sixth inventor's signature Date Yasuhiko Ozawa Nov. 1, 2000
住所		Residence Hitachinaka, Japan JPX
国籍		Citizenship Japan
私書箱		Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第七共同発明者	7-00	Full name of seventh joint inventor, if any Hideka BANBA
第七共同発明者の署名	日付	Seventh inventor's signature Date Hideka Banba 11/7/2000
住所		Residence Hitachinaka, Japan JPX
国籍		Citizenship Japan
私書箱		Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第八共同発明者	8-00	Full name of eighth joint inventor, if any Kenji WATANABE
第八共同発明者の署名	日付	Eighth inventor's signature Date Kenji Watanabe 10/31/2000
住所		Residence Kodaira, Japan JPX
国籍		Citizenship Japan
私書箱		Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan
第九共同発明者	9-00	Full name of ninth joint inventor, if any Chie SHISHIDO
第九共同発明者の署名	日付	Ninth inventor's signature Date Chie Shishido Oct. 16, 2000
住所		Residence Yokohama, Japan JPX
国籍		Citizenship Japan
私書箱		Post Office Address c/o Hitachi, Ltd., Intellectual Property Group New Marunouchi Bldg. 5-1, Marunouchi 1-chome, Chiyoda-ku, Tokyo 100-8220, Japan

(第十以降の共同発明者についても同様に記載し、署名をすること)

(Supply similar information and signature for tenth and subsequent joint inventors.)